

IAPI6 Rec'd PCT/PTO 18 SEP 2006

10/593158

MAIL STOP PCT

Attorney Docket No. 27678U

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Application of:

RATNAM et al.

International Application No. PCT/IN2004/000142

Serial No. NOT YET ASSIGNED

International Filing Date: 20 May 2004 (20.05.2004)

Filed: September 18, 2006

For: **AN IMPROVED PROCESS FOR PRODUCING CHLORINATED SUCROSE**

STATEMENT UNDER 37 CFR § 1.125

Commissioner for Patents  
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Alexandria, VA 22313-1450

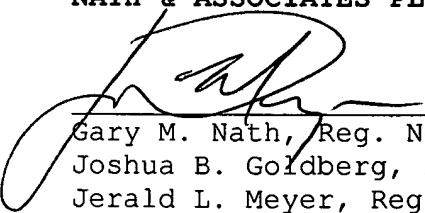
Sir:

I hereby state that the accompanying clean copy of the substitute specification contains no new matter over that contained in the above-identified application as originally filed.

I further state that the changes made are the same as indicated in the marked up copy of the original specification also accompanying this statement.

Respectfully submitted,

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10/593158

Mail Stop PCT  
Attorney docket 27678U  
Clean Substitute Specification

**TITLE**

AN IMPROVED PROCESS FOR PRODUCING CHLORINATED SUCROSE

**TECHNICAL FIELD**

This invention relates to an improved process for producing chlorinated  
5 sucrose

**BACKGROUND OF THE INVENTION**

Chloro derivatives derived from sugars, exhibit the organoleptic properties with a very high degree of sweetness compared to the parent sugar. One such chloro sugar prepared from sucrose is 1', 6'-Dichloro-1', 6'-Dideoxy- $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside. It is a well-  
10 known sweetener used widely, including in food and food preparations. Various synthetic routes for the production of 1', 6'-Dichloro-1', 6'-Dideoxy- $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside are reported in literature, for e.g. Fairclough et al, Carbohydrate Research 40(1975) 285-298;  
15 Mufti et.al. 1983 US Patent No. 4,380,476; Walkup, et al. 1990 US Patent no. 4,980,463 and British Patent No. 1543167. They involve preparing derivatives of sucrose, chlorinating them and to recover the desired product, chlorinated sucrose, by reversing derivatization. Preferred processes involve converting sucrose into acetate, chlorination of the acetate, deacylation of the  
20 chlorinated acetate and recovering the product from reaction mixture.

A major challenge in these approaches is to separate the desired product, 1',  
6'-Dichloro-1', 6'-Dideoxy-â-D-Fructo-Furanosyl-4-Chloro-4-Deoxy-â-D-  
Galactopyranoside from the chlorinated mass, from other chloro derivatives of  
sucrose, salts formed during reaction, dark degradation products and tars  
5 formed on account of oxidation and elimination due to the relatively severe  
conditions of chlorination reaction, and finally all these solid components from  
the large volume of liquids consisting of solvents such as tertiary amide.

Processes for production of this compound reported in patent literature are all  
based on handling these liquid reaction mixtures by subjecting them, in liquid  
10 state itself, to selective liquid-liquid extraction by using organic solvents,  
column chromatographic purification of the solvent extracts, and the  
intermediate derivatives and / or the chlorinated sucrose is recovered by  
conventional crystallization procedure. The procedures used so far for  
removal of tertiary amides from these liquid reaction mixtures as well as  
15 conventional crystallization are very elaborate, cumbersome to operate and  
control and expensive on account of the cost of equipment needed and  
energy required to run the processes.

Navia et al, 1996 US Patent No. 5498709 describes a process for preparing  
chlorinated sucrose where removal of tertiary amide from the liquid reaction  
20 mixture is done by steam distillation. However, the solvent being a high  
boiling point, it takes a very long time for it to be stripped off to the maximum  
limits. Also it is reported in the same patent that the volumes of the mass

increases to 4 to 5 times of the original volume. This increase in volume also increases the time for isolation of the product as well as increases size of the processing plant to that extent for handling the resultant volume of reactants for further processing.

- 5 An improved process, having several potential economic advantages, for preparation of chlorinated sucrose is disclosed in co-pending application No: PCT/IN04/0064. This improved process described recovery of solids, from liquids containing chlorinated sucrose or its intermediates with or without other solids, obtained in a process for producing chlorinated sucrose or
- 10 otherwise, mainly 1', 6'-Dichloro-1', 6'-Dideoxy- $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy Galactopyranoside by using drying, under mild controlled conditions by industrially used processes, as a more efficient and more effective tool. The described drying process, is applicable to any liquid solution obtained as reaction mixture or purified solution in course of any
- 15 process including in the course of process for production of chlorinated sucrose or its intermediates. The drying methods which are subject of this co-pending application include, but are not limited to, agitated thin film drying (ATFD), spray drying, freeze drying and super critical extraction. The preferred drying process used in co-pending application was ATFD.
- 20 The drying method, as applied in the preceding para has been very effectively used in improving efficiency of operation of post-chlorination steps and recovery of final product intermediate (acetate) and final product in pure solid

form. Drying of reaction mixture after completion of chlorination reaction achieved total removal of tertiary amides from the system in a most convenient and most effective way in very short time and better control is obtained on volumes to be handled and effective application of post  
5 chlorination steps such as deacylation. Drying also affords a most convenient and more effective and more efficient alternative to batch or continuous processes (some of which described by Navia, et al., U.S. Pat. No. 5,498,706; Mufti, et al., U.S. Pat. No. 4,380,476) of crystallization based on conventional cumbersome crystallization procedures used so far for recovery of final  
10 product intermediate or final product from purified liquids obtained in course of production process. The final powder of the product or product intermediate obtained by drying process is amorphous in nature and not crystalline as in conventional crystallization procedure, both having same organoleptic taste and chemical analysis. However, the amorphous powder obtained in the  
15 invented process shall have different physical properties such as free-flowing powder properties, different storage properties than the crystalline variety. In that sense, amorphous powder is a new product and its properties are being studied.

#### **SUMMARY OF INVENTION**

20 In present invention, which is in continuation with the invention disclosed in co-pending application no. PCT/IN04/0064, it was found that efficiency improvement achieved by improvements claimed in the above mentioned co-

pending application improves further and becomes more flexible by introducing following alternative routes of further process:

- i) Adjusting the pH of the reaction mixture after chlorination to a variety of chosen alkaline ranges, well below pH 11, either neutralization to pH 7.0 to 7.5, or adjusting to pH 7.5 to 9.
- ii) Deacylation being done either before or after drying the reaction mixture by drying methods including agitated thin film drying (ATFD).
- iii) Use of alkoxides in the steps for deacylation.

These steps have been very effectively combined with mild methods of drying claimed in PCT/IN04/0064 application of the applicants of this patent application to construct very efficient alternative routes for production of chlorinated sucrose having high potential of economic advantages. Some of the alternative routes constructed are as follows:

1. Drying directly the reaction mixture of chlorination step being undertaken of the whole reaction mixture solution either by direct feeding at pH 7.0 to 7.5, or after adjustment of pH to 7.5 to 9.0 or after deacylation step.
2. Drying directly the wash liquid collected from chromatography or any separation method resulting into a purified solution of chlorinated sucrose or its intermediate or derivative for recovery of the product or the product derivative in solid powder form;

3. Dissolving the ATFD dried solids of the chlorination reaction mixture in water, extracting the same in appropriate organic solvent, and drying the solvent extract by ATFD to recover the product or product intermediate in solid powder form;

5 4. Concentrating the solvent extract obtained in any step of production of chlorinated sucrose, and drying the concentrated extracts to recover the product or product intermediate in solid powder form; or

5. Drying the solution of chlorinated sugar, its derivatives or intermediates obtained otherwise than in the process of production of chlorinated  
10 sugars.

The detailed description and the specific examples given in a subsequent section, for the purpose of indicating specific embodiments of the invention, serve the purpose of illustration only. Accordingly, the present invention includes also those various changes and modifications which come within the  
15 spirit and scope of the invention that may become obvious to those skilled in the art from this detailed description.

#### **BRIEF DESCRIPTION OF DRAWINGS AND SHORTFORMS**

POCL<sub>3</sub> (POCl<sub>3</sub>) stands for Phosphorous oxy-chloride

ATFD stands for Agitated Thin Film Dryer

20 TLC stands for Thin Layer Chromatography

HPLC stands for High Pressure Liquid Chromatography

Fig. 1 illustrates the reaction scheme for the preparation of 1', 6'-Dichloro-1', 6'-

Dideoxy - $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside.

5 Fig. 2 illustrates the agitated thin film dryer used in the process of the present invention,

Fig. 3 is the flow sheet of the agitated thin film dryer;

Fig. 4 is the flow chart of the process of the present invention,

Fig. 5 is the IR Report of the product of the present invention; and

10 Fig. 6 is the HPLC Chromatogram of the product of the present invention.

Fig 7 is the XRD of crystalline form.

Fig 8 is the XRD of amorphous form.

15 **DETAILED DESCRIPTION OF THE INVENTION**

It is understood that the customary rules of interpretation of patent documents apply to this document also. However, some of those interpretations, which will expressly apply, are mentioned below.

Present invention is not limited to the particular methodologies, protocols, solvents, and reagents, etc, described herein as tools to achieve the claimed  
20 objective, as these may vary with change in context. Further, the terminology



used herein is used for the purpose of describing particular embodiments only, and is not intended to and shall not limit the scope of the present invention.

As used herein and in the appended claims, the singular forms "a" "an" and "

5 the" include plural reference also unless the context clearly indicates or requires or means otherwise. Thus, for example, a reference to "a process" is a reference to one or more processes for the stipulated objective and includes equivalents thereof known or obvious to those skilled in the art and so forth. Unless defined otherwise or contrary to the context, all technical and scientific  
10 terms used herein have the same meanings as commonly understood by one of ordinary skill in the art to which this invention belongs. Several methods, devices, and materials are described herein, although in practice or for testing of present invention, any methods and materials similar or equivalent to those described herein can be used. All documents cited herein are to be construed  
15 for reference and interpretation herein in their entirety

The process of drying under mild conditions applied to any liquid containing chlorinated sucrose derivative, either in substantially pure form or with other accompanying solid ingredients, is illustrated in Fig 4. Strategic use of some important modifications and the advantages of these modifications and  
20 subjecting the liquid solutions subjected to direct drying under mild conditions and certain other modifications introduced in the process, in the context of process efficiency, are as follows:

1. The reaction mixture of chlorination step, after completion of the reaction, can be subjected to drying under mild conditions either after or before deacylation step. This brings in significant improvement in process efficiencies, as it is more easy to handle a dry powder for further purification of the chlorinated sucrose or its intermediate in absence of solvent than in presence of solvent. It is pertinent to mention that the final product as well as inorganic salts formed during the process are both highly soluble in water. Hence, to extract the desired product completely from aqueous medium may be a difficult proposition. However, the extraction of solids (comprising of desired product or its intermediate and inorganic salts) by alcoholic organic solvent is better solution as selective extraction of the desired product will be more easy. The drying process requires less equipment, less consumption of energy, offers freedom from tediousness of crystallization processes in a batch or continuous operation. Several alternative procedures are available to adopt further course of operation either by extracting the chlorinated sucrose or its intermediate either by using a suitable organic solvent, ethyl acetate being preferable, or by supercritical extraction, or by dissolving the solids in water and subjecting the same to purification by column chromatography. Removal of the solvents by drying in above step is more convenient than by steam stripping adopted by Navia et al., in U.S. Pat. No. 5,498,709.
2. Further, once substantially pure solution of chlorinated sucrose or its intermediates or derivatives is obtained in the course of process of their

production, recovery of the product is very convenient, direct, total and most effective by resorting to drying under mild conditions than by recovering desired product by conventional crystallization from their concentrated solutions of those products as such or of their derivatives.

5 The process of drying gives substantially pure product directly in one step process in short time with least problems of control without any residual losses of solids; their purity, chemical properties and functional properties such as taste are same as the product obtained by conventional crystallization. This is a decided advantage in view of the  
10 cumbersomeness and expenses involved in conventional crystallization and in any process based on conventional crystallization.

3. Such substantially pure solutions of chlorinated sucrose or their intermediates, which could be submitted to drying under mild conditions for recovery of their solids for specific processing advantages, are  
15 obtained in the process illustrated in Fig 4 in the form of wash liquid coming out of chromatographic column when extracts obtained from solids of drying of chlorination reaction mixture are chromatographed and such wash liquid is evaporated and dissolved in appropriate volume of methanol.

20 In the methods preferred here for the illustration of this invention:

1. The chlorinated sucrose is 1', 6'-Dichloro-1', 6'- Dideoxy- $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside and also its acetate intermediates.

2. Sucrose-6-ester is sucrose-6-acetate.

3. The method of drying under mild conditions is Agitated Thin Film Drying, which involves evaporation achieved by using a vertical agitated thin film evaporator with hinged rotor blades.

4. The reaction scheme in general involved in the manufacture of product from sucrose-6- acetate is given in fig. 1 of the accompanying drawings.

Many permutations and combinations could be done in the indicated scheme, some of which, but not including all, are shown as illustration in the fig 1.

Various operations of the process of production of 1', 6'-Dichloro-1', 6 '-Dideoxy- $\alpha$ -D-Fructo- Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside are as follows:

The sucrose-6-acetate is chlorinated by the Vilsemeier reagent, which is prepared from Phosphorus Oxy Chloride (POCl<sub>3</sub>) or phosphorus penta chloride (PCl<sub>5</sub>). The sucrose-6-acetate is added to Vilsmeier Reagent at 5.degree.to 10.degree.C. After completion of the reaction, the reaction mass is heated to 80.degree. to 100.degree.C. and preferably between 90.degree.to 95.degree.C. and maintained for ½ -1hr and then the

temperature is raised to 110.degree.to135.degree.C. and preferably to 120.degree.to125.degree.C. and maintained for 3-5 hours.

Thereafter the reaction mass is cooled to room temperature and neutralized using alkali hydroxide or carbonate solution.

- 5 The desired product 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-  $\alpha$  -D-Galactopyranoside or its acetate, obtained after or before deacylation respectively, could be isolated by using the appropriate method mentioned in Methods 1 to 5 given as follows:

**Method 1:** When the reaction mass after chlorination is directly fed into  
10 ATFD, the product obtained was a solid mixture of 1', 6'-Dichloro-1',6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$  -D-Galactopyranoside-6-acetate and inorganic salts. The solids were treated with alcoholic solvents and filtered off to remove the inorganics. The alcoholic solution was then heated with appropriate organic alkoxides like sodium  
15 methoxide, sodium ethoxide, propoxides or its potassium analogs, during which the deacylation occurs to afford the desired product. The product could be isolated as a solid by either subjecting the alcoholic solution to the ATFD or the alcoholic solution could be further purified by column chromatography and the liquid eluted from the chromatographic column could be subjected to  
20 crystallization or direct drying by subjecting to ATFD.

**Method 2:** The solid mixture of 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-Chloro-4-Deoxy-6-acetoxy-  $\alpha$  -D-Galactopyranoside-6-acetate and

inorganic salts from the reaction mixture could be dissolved in water or the reaction solution can be further treated directly without ATFD drying with the alkali metal oxides like sodium hydroxide or potassium hydroxide or even with alkali earth metals like calcium hydroxide or barium hydroxide, etc. The resultant solution could be fed into the ATFD or spray drier to remove water and afford solids, where now essentially will be comprising of 1', 6'-Dichloro-1',6'-Dideoxy- $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside (the product) and alkali or alkaline earth metal chlorides (NaCl, KCl or CaCl<sub>2</sub>). The product can be separated from inorganic chlorides by extracting the solids by organic solvents like methanol, ethyl acetate, acetone, etc and the product in the solvent extract can be further purified by column chromatography followed by crystallization or drying in ATFD.

**Method 3:** Yet another appropriate process was followed by adjusting the reaction mass to pH 7.5 – 9.0 and then subjecting the reaction mass to ATFD for solvent stripping. The product obtained being the mixture of desired deacylate of 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate and inorganic salts. Effectively the deacylation was achieved in situ during the solvent stripping operations of ATFD. The solids obtained were treated with organic solvents to remove inorganic salts. The crude product after solvent stripping either by spray drying or ATFD was further purified after extracting solids in alcoholic solvents by column chromatography followed by crystallization or subjecting the chromatography column eluate to ATFD drying.

**Method 4:** Isolation of the pure 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate from solids containing 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate and inorganic salts in a process mentioned in methods 1 and 2 could also be achieved by direct column chromatography of the salts obtained from ATFD or spray drier.

**Method 5:** Isolation of the pure 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate from solids containing 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate and inorganic salts could also be achieved by dissolving the solids with water and extracting with organic solvents like dichloromethane, ethyl acetate and then stripping of solvent by drying by ATFD to get crude solid mixture. Isolation of the pure 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside from solids containing 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate can be achieved after followed by deacylation as mentioned in method 1 and 2.

**Method 6:** Isolation of the product 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-  $\alpha$ -D-Galactopyranoside from solids containing 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-  $\alpha$ -D-Galactopyranoside and inorganic salts could be done by dissolving the solids

obtained by using process described in Method 3 in water and extracting the product in organic solvent like ethyl acetate, dichloromethane, etc. This was followed by solvent stripping, column chromatography and crystallization.

Diagram of ATFD is shown in Fig. 2 of the drawings.

5 The detailed preferred process of ATFD is illustrated as follows:

Feed of the reaction mass was cooled to 5.degree.to10.degree.C. in the feed tank by circulating a brine solution. A pump was used to lift the feed from feed tank to the Dryer. The ATFD is a vertical Dryer with area of cross section 0.25 to 0.35 meter sqare. The feed enters tangentially and spreads along  
10 the inside surface of the shell in to a thin film. The rotor blades are hinged; the hinged rotor blades keep the film under intense agitation preventing any scale formation. The speed of the rotor was 1000 to 1500 revolutions per minute. The film progressively passes through different phases like liquid, slurry, paste, wet powder and finely powder of desired dryness, it is collected in a  
15 powder receiver.

The vapor flows countercurrent to the solids and was removed from the top of the Dryer. Distillate was collected from the condenser and solids are obtained from the Dryer. The distillate contains solvent and water. The distillate was subjected to fractional distillation, about 70-80% of solvent was recovered  
20 based on the input of solvent.



## **EXPERIMENT**

### **1. CHLORINATION OF SUCROSE-6-ACETATE**

100 g of sucrose-6-acetate was mixed with 200 ml of fresh solvent such as hexane, cyclohexane, pyridine, dimethyl formamide, and others, and particularly dimethyl formamide and Chlorination undertaken in a 3 liter 3  
5 neck round bottom flask. 500 ml of the solvent was charged. Thereafter, the solvent was cooled with stirring to 0.degree.to 5.degree.C. To this reaction mass, 166 ml of phosphorous oxy chloride (273.9 g) was added below 0.degree.C. To this chlorinating reagent, 100gm of sucrose 6-acetate in  
10 solvent was added below 10.degree.C. Thereafter, the reaction mass was stirred at 20.degree.to 25.degree. C. for ½-1 hr. Further, the temperature was raised to 70.degree.to 100.degree.to C. and preferably 80.degree.to 90.degree.C. and was maintained for 1 to 2 hr. Afterwards the temperature was raised to 110.degree.to 130.degree.C. and preferably 120.degree.to  
15 122.degree.C. and was maintained for 3 to 5 hr. The reaction mass was cooled to 40.degree.to 45.degree.C. and was neutralized.

### **2. ATFD REMOVAL OF SOLVENT**

The reaction mass obtained after completion of chlorination reaction, which approximates volume of 2-2.3 liter, was further treated in one of the following,  
20 including but not limited to, two alternatives:

a) pH is adjusted to 7.0-7.5 to obtain mixture of 1', 6'-Dichloro-1',6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$  -D-Galactopyranoside-6-acetate and inorganic salts;

b) pH is adjusted to 7.5 –9.0 to obtain mixture of 6-acetyl intermediate  
5 of 1',6'-Dichloro-1',6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-  $\alpha$  -D-Galactopyranoside and inorganic salts;

and the reaction mass was then fed to ATFD with the parameters, which are described, but not limited to, as follows:.

Area of ATFD = 0.20 - 0.50 meter square

10 Feed rate = 7-10 kg/hr

Pressure = 2 – 10 mm Hg.

Jacket temp = 70.degree.to100.degree.C.

Feed of 3 to 5 kg was cooled down to 5.degree.to 10.degree.C. in the feed tank by circulating the brine solution. pH of the feed was maintained at 7.0 to  
15 7.5 or 7.5 to 9; the pump was fitted to lift the feed from feed tank to the dryer. The dryer is a vertical dryer with area of cross section 0.25-0.35 square Meter. The feed entered tangentially and spreads along the inside surface of the shell in to a thin film. The rotor blades are hinged, the hinged rotor blades keep the film under intense agitation preventing any scale formation. The  
20 speed of the rotor was 1000-1500 revolutions per minute. Temperature was

maintained around 70.degree.to 100.degree.C. in the jacket by circulating hot water taking inlet from bottom, outlet through the top. The film progressively passed through different phases like liquid, slurry, paste, wet powder and finely powder of desired dryness. This was collected in a powder receiver.

- 5 The dry product, which was essentially, a mixture of 1', 6'-Dichloro-1', 6 '-Dideoxy- â -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy- â -D-Galactopyranoside-6-acetate and inorganic salts or alternatively deacylated 1', 6'-Dichloro-1', 6 '-Dideoxy- â -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy- â -D-Galactopyranoside-6-acetate and inorganic salts. This depends on the  
10 respective feed to the ATFD as described above.

The vapor flows countercurrent to the solids and was removed from the top of the Dryer. These vapors were condensed in the condenser. Distillate was collected from the condenser, solids were obtained from the Dryer. The distillate contains solvent and water.

- 15 The distillate was subjected to fractional distillation, about 70-80% of solvent was recovered based on the input of solvent.

**3. RECOVERY OF 1', 6'-DICHLORO-1', 6'-DIDEOXY -  $\alpha$  -D-FRUCTO-FURANOSYLI-4-CHOLOR-4-DEOXY-  $\alpha$  -D-GALCTOPYRANOSIDE FROM 6-ACETYL INTERMEDIATE, ITS DEACYLATION AND RECOVERY OF FINAL PRODUCT :**

5 This was achieved in four alternative ways exemplified as follows:

**3.1** The pH of the reaction mass after chlorination was adjusted to 7.0 – 7.5.

The reaction mass was subjected to ATFD to obtain 450g of mixture of 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$  -D-Galactopyranoside-6-acetate and other inorganic salts. This powder  
10 was dissolved in 1.2 liters of water and complete dissolution was ensured. The solution was then extracted with 1 liter of ethyl acetate and layers separated. The aqueous solution was re-extracted with 400ml of ethyl acetate three times and all the ethyl acetate layers were pooled. The ethyl acetate was distilled off and the residue obtained was purified by column  
15 chromatography on silica gel. The purified 6-acetyl intermediate was deacylated with 10% sodium methoxide solution in methanol (pH 9 –10).

The deacylated product was concentrated and crystallized to obtain pure 1', 6'-dichloro-1', 6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-  $\alpha$  -D-Galactopyranoside of 98.6% purity by HPLC and yield 30%.

20 **3.2** 450 g solids obtained from the ATFD which contains the 6-acetyl intermediate of 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-  $\alpha$  -D-Galactopyranoside and the inorganic salts were

dissolved in 500ml methanol three times. The methanolic extract was filtered to remove the inorganic salts.

The methanolic solution containing 6-acetyl product was treated with sodium methoxide at room temperature and was mixed till complete deacetylation.

5 The product was then concentrated to thick syrup and was taken for silica gel column chromatography. The purified fractions were collected, concentrated and crystallized to get pure product of 98.9% and yield 34%.

3.3 The pH of the chlorinated mass was adjusted to 8.5 – 9.0 and was fed to the ATFD. Solids obtained from ATFD, 450g, were extracted into 500 ml  
10 methanol three times. The methanol extract was filtered and concentrated and the residue was purified by silica gel column chromatography. The product obtained was 92% pure.

3.4 Solids from ATFD of the step of drying in example 3, 450g, were dissolved in 1.2 liter water and then extracted into 1:1 ethyl acetate. The aqueous solution  
15 was further extracted with 400 ml of ethyl acetate thrice. The ethyl acetate layers were pooled together and concentrated. The thick syrup obtained was purified by column chromatography to yield pure product of 93%.

#### 4. CHROMATOGRAPHIC PURIFICATION AND CHARCOALIZATION

Purification of liquids containing product or product intermediates with  
20 impurities was purified by column chromatography on silica gel or alumina using appropriate elution / desorption medium. The eluent coming out of the

column was given charcoal bed treatment and was then sent for either ATFD drying or for conventional crystallization.

#### **5. EXTRACTION OF PRODUCT FROM SOLIDS OBTAINED AFTER ATFD DRYING OF PURIFIED LIQUIDS CONTAINING THE PRODUCT**

- 5 The solid mass obtained from the ATFD, when the liquid subjected to drying contained almost pure product, was subjected to solvent extraction. The solvent used may be any organic solvent, including but not limited to, ethyl acetate, methanol, methyl ethyl ketone, and acetone. The preferred solvent used was methanol.
- 10 The solvent extracted mass was distilled in the rotary evaporator at low temperature. The syrup obtained was mixed with an appropriate column chromatography adsorbent like silica gel or alumina and run through column chromatography. The adsorbing agent could be any known column packing preferably alumina or silica gel. The preferable solvents for desorption are
- 15 ethyl acetate, mixture of toluene and methanol, mixture of methanol and ethyl acetate, mixture of methanol and dichloromethane. Ethyl Acetate was used in this work. The eluted fractions were collected in different receivers based on TLC showings. The fractions showing single spot on the TLC were collected separately. The solvent from this fraction was evaporated to provide a thick
- 20 syrup. The thick syrup was subjected to purification. Crude product obtained showed by TLC to have a high concentration of the desired product. This was subjected to crystallization.

The products that are extracted and purified by the above processes were and could be any one of the following i.e. 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate or its deacylated form i.e. 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-  
5 Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside.

## **6. ISOLATION OF PRODUCT ACETATE OR THE PRODUCT IN POWDER FORM**

- 10 The syrup obtained from the isolation stage was mixed with 3-5 volumes of mass of ethyl acetate and mixed well. The mass was distilled at low temperature to remove 2-4 volumes of ethyl acetate resulting in a liquid product concentrate. The desired dry product was obtained from the liquid concentrate by three methods,
- 15 a) Conventional crystallization, as reported as in the earlier patents cited in this document. Essential steps consisted of solvent distillation to form a product syrup, which was then dissolved in minimum quantity of appropriate solvent and then seeded with the product crystals for crystallization. The pure Crystals were recovered by centrifugation.
- 20 b) Feeding liquid product concentrate to ATFD to obtain the dry desired pure product of the acetyl intermediate or the desired deacylated product. This has

been reported for the first time in the co-pending application of these applicants No. PCT/N04/D064.

c) Spray drying the liquid product concentrate to obtain of the acetyl intermediate or the desired deacylated product, which has also been reported  
5 for the first time in the co-pending application of these applicants No. PCT/N04/D064.

In the conventional crystallization method the liquid concentrate was crystallized to obtain solid product. The product was filtered and dried under vacuum at 40.degree.to 50.degree. C.

10 **7. PROPERTIES OF THE PRODUCT OBTAINED THROUGH ABOVE EXPERIMENTS**

The solids isolated after drying the purified product containing liquids in the ATFD were also found to be identical in taste, organoleptically, and chemical analysis with the product obtained from the conventional crystallization method. Also the  
15 solids obtained after spray drying the liquid concentrate were found to be identical in taste and chemical purity with the desired pure product obtained from the crystallization and ATFD method. Solid powders obtained by ATFD and other methods of drying when compared to powders obtained from crystallization procedures were, however, amorphous in nature having smaller particle size.  
20 The average particle size of chlorinated sucrose, its derivatives and its intermediates was observed to be less than 20 microns, average particle size within a range of 5 micron to 12 microns, the residual moisture content was less



than 10%, more particularly to less than 5% and usually less than 0.5% up to 0.3%. This small particle size is obtained directly in crystallization or precipitation procedure and is not result of any milling after the crystals are obtained. The powder which appears as amorphous may also a microcrystalline in nature and  
5 composed of full range of particle shapes from totally amorphous though globular shapes to well defined needles. The product may further be milled to achieve more uniform particle size distribution. Residual solvent content of the product produced by the process describe above was below 0.1% usually 0.09%.

10 The crystalline form of the product is confirmed with the XRD plot as shown in Fig 7.

The particle size was evaluated in Microtrac – X100 equipment.

Properties of some of the batches of products are given below:

15

Table 1: Properties of conventional crystallization batch in process described in experiment no. (6.a):

Sl. No	TEST	RESULTS	SPECIFICATION
01	Appearance	White coloured crystals, taste sweet.	White to off white crystals, taste sweet.
02	Solubility	Complies	Soluble in ethanol and water. Slightly soluble in ethyl acetate.
03	Particle size		90% ≤ 9 microns
04	Specific Rotation	+86.03 <sup>0</sup>	Between +84 <sup>0</sup> to +87.5 <sup>0</sup>
05	Water content	0.22%	NMT 2%
06	Residue on ignition	0.04%	NMT 0.7%

07	Identification by IR	Complies	Complies with standard.
08	Identification by TLC	Complies ( Rf of both std & sam =0.72 cm)	Rf should complies with std
09	Other chlorinated disaccharides	Complies	NMT 0.5%
10	Chlorinated monosaccharides	Complies	NMT 0.1%
11	Triphenylphosphine oxide	Complies	NMT 150 µg/g
12	Methanol	0.09%	NMT 0.1%
13	Organoleptic	Passes the test	Passes the test
14	Purity	99.65%	NMT 98%
15	Arsenic	Complies	NMT 3 ppm
16	Heavy metals	Complies	NMT 0.001%
<b>MICROBIOLOGICAL SPECIFICATIONS</b>			
21	Total aerobic count	Nil	NMT 250/g
22	Yeasts	Nil	NMT 50/g
23	Molds	Nil	NMT 50/g
24	<b><u>Coliforms</u></b>	Nil	Negative test
25	<i>E.Coli</i>	Nil	Negative test
26	<i>S.aureus</i>	Nil	Negative test
27	<i>Salmonella</i>	Nil	Negative test

Table 2: The table below gives the data with respect to the individual crystal particle and their percentage

5

10%	0.956	60%	4.236
20%	1.541	70%	5.311
30%	2.093	80%	6.615
40%	2.605	90%	9.185
50%	3.274	95%	11.51

It is conclusive from the above results that the particle size of 90% of the crystallized product is below 9.185 microns.

10 Table 3: Summary results on particle size obtained from some other batches

Batch No.	Particle size
PP 02	90% $\leq$ 9.125 microns
PP 03	90% $\leq$ 9.165 microns
PRO 01	90% $\leq$ 9.035 microns
PRO 05	90% $\leq$ 9.183 microns

The particle size of crystals thus obtained from ethyl acetate crystallization conforms to the specifications.

- 5 Properties of amorphous product obtained by direct drying methods such as ATFD and spray drying:

The average particle size of chlorinated sucrose, its derivatives and its intermediates as was obtained from ATFD and or spray drying was observed to be less than 15 microns, average particle size within a range of 5 micron to 12  
10 microns, the residual moisture content was less than 10%, more particularly to less than 5% and usually less than 0.5% up to 0.3%. This small particle size is obtained directly after the said drying process and is not subjected to any milling after the dried powder is obtained. Also the spray drying or ATFD can be carried out on the pure product as well as in mixture with other suitable diluents or  
15 formulating agents. The powder which appears as amorphous may contain solvent content of below 0.1% usually 0.09%.

The XRD plot as shown in the figure no. 8 indicates no regular pattern, without any peaks, confirming that the product is amorphous in nature.

20

The chemical analysis of the solids from all the three methods showed the product purity or content was over 99% (HPLC Fig. 6 and IR Fig. 5 attached).

In a separate experiment, the ethyl acetate extract from after column chromatography was directly passed through ATFD. This also resulted in a desired pure product of high purity.

The solid product could be also isolated by feeding the ethyl acetate extract  
5 after column chromatography directly into the Spray Dryer or any other Dryer  
to afford the solid product.

**TITLE**

AN IMPROVED PROCESS FOR PRODUCING CHLORINATED SUCROSE

**TECHNICAL FIELD**

This invention relates to an improved process for producing chlorinated  
5 sucrose

**BACKGROUND OF THE INVENTION**

Chloro derivatives derived from sugars, exhibit the organoleptic properties  
with a very high degree of sweetness compared to the parent sugar. One  
such chloro sugar prepared from sucrose is 1', 6'-Dichloro-1', 6'-Dideoxy- $\alpha$ -  
10 D-Fructo-Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside. It is a well-  
known sweetener used widely, including in food and food preparations.  
Various synthetic routes for the production of 1', 6'-Dichloro-1', 6'-Dideoxy- $\alpha$ -  
D-Fructo-Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -Galactopyranoside are reported in  
literature, for e.g. Fairclough et al, Carbohydrate Research 40(1975) 285-298;  
15 Mufti et.al. 1983 US Patent No. 4,380,476; Walkup, et al. 1990 US Patent no.  
4,980,463 and British Patent No. 1543167. They involve preparing derivatives  
of sucrose, chlorinating them and to recover the desired product, chlorinated  
sucrose, by reversing derivatization. Preferred processes involve converting  
sucrose into acetate, chlorination of the acetate, deacylation of the  
20 chlorinated acetate and recovering the product from reaction mixture.

A major challenge in these approaches is to separate the desired product, 1',  
6'-Dichloro-1', 6'-Dideoxy-â-D-Fructo-Furanosyl-4-Chloro-4-Deoxy-â-D-  
Galactopyranoside from the chlorinated mass, from other chloro derivatives of  
sucrose, salts formed during reaction, dark degradation products and tars  
5 formed on account of oxidation and elimination due to the relatively severe  
conditions of chlorination reaction, and finally all these solid components from  
the large volume of liquids consisting of solvents such as tertiary amide.

Processes for production of this compound reported in patent literature are all  
based on handling these liquid reaction mixtures by subjecting them, in liquid  
10 state itself, to selective liquid-liquid extraction by using organic solvents,  
column chromatographic purification of the solvent extracts, and the  
intermediate derivatives and / or the chlorinated sucrose is recovered by  
conventional crystallization procedure. The procedures used so far for  
removal of tertiary amides from these liquid reaction mixtures as well as  
15 conventional crystallization are very elaborate, cumbersome to operate and  
control and expensive on account of the cost of equipment needed and  
energy required to run the processes.

Navia et al, 1996 US Patent No. 5498709 describes a process for preparing  
chlorinated sucrose where removal of tertiary amide from the liquid reaction  
20 mixture is done by steam distillation. However, the solvent being a high  
boiling point, it takes a very long time for it to be stripped off to the maximum  
limits. Also it is reported in the same patent that the volumes of the mass

increases to 4 to 5 times of the original volume. This increase in volume also increases the time for isolation of the product as well as increases size of the processing plant to that extent for handling the resultant volume of reactants for further processing.

- 5 An improved process, having several potential economic advantages, for preparation of chlorinated sucrose is disclosed in co-pending application No: PCT/IN04/0064. This improved process described recovery of solids, from liquids containing chlorinated sucrose or its intermediates with or without other solids, obtained in a process for producing chlorinated sucrose or
- 10 otherwise, mainly 1', 6'-Dichloro-1', 6'-Dideoxy- $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy Galactopyranoside by using drying, under mild controlled conditions by industrially used processes, as a more efficient and more effective tool. The described drying process, is applicable to any liquid solution obtained as reaction mixture or purified solution in course of any
- 15 process including in the course of process for production of chlorinated sucrose or its intermediates. The drying methods which are subject of this co-pending application include, but are not limited to, agitated thin film drying (ATFD), spray drying, freeze drying and super critical extraction. The preferred drying process used in co-pending application was ATFD.
- 20 The drying method, as applied in the preceding para has been very effectively used in improving efficiency of operation of post-chlorination steps and recovery of final product intermediate (acetate) and final product in pure solid

form. Drying of reaction mixture after completion of chlorination reaction achieved total removal of tertiary amides from the system in a most convenient and most effective way in very short time and better control is obtained on volumes to be handled and effective application of post  
5 chlorination steps such as deacylation. Drying also affords a most convenient and more effective and more efficient alternative to batch or continuous processes (some of which described by Navia, et al., U.S. Pat. No. 5,498,706; Mufti, et al., U.S. Pat. No. 4,380,476) of crystallization based on conventional cumbersome crystallization procedures used so far for recovery of final  
10 product intermediate or final product from purified liquids obtained in course of production process. The final powder of the product or product intermediate obtained by drying process is amorphous in nature and not crystalline as in conventional crystallization procedure, both having same organoleptic taste and chemical analysis. However, the amorphous powder obtained in the  
15 invented process shall have different physical properties such as free-flowing powder properties, different storage properties than the crystalline variety. In that sense, amorphous powder is a new product and its properties are being studied.

#### **SUMMARY OF INVENTION**

20 In present invention, which is in continuation with the invention disclosed in co-pending application no. PCT/IN04/0064, it was found that efficiency improvement achieved by improvements claimed in the above mentioned co-



pending application improves further and becomes more flexible by introducing following alternative routes of further process:

- i) Adjusting the pH of the reaction mixture after chlorination to a variety of chosen alkaline ranges, well below pH 11, either neutralization to pH 7.0 to 7.5, or adjusting to pH 7.5 to 9.
- ii) Deacylation being done either before or after drying the reaction mixture by drying methods including agitated thin film drying (ATFD).
- iii) Use of alkoxides in the steps for deacylation.

These steps have been very effectively combined with mild methods of drying claimed in PCT/IN04/0064 application of the applicants of this patent application to construct very efficient alternative routes for production of chlorinated sucrose having high potential of economic advantages. Some of the alternative routes constructed are as follows:

1. Drying directly the reaction mixture of chlorination step being undertaken of the whole reaction mixture solution either by direct feeding at pH 7.0 to 7.5, or after adjustment of pH to 7.5 to 9.0 or after deacylation step.
2. Drying directly the wash liquid collected from chromatography or any separation method resulting into a purified solution of chlorinated sucrose or its intermediate or derivative for recovery of the product or the product derivative in solid powder form;

3. Dissolving the ATFD dried solids of the chlorination reaction mixture in water, extracting the same in appropriate organic solvent, and drying the solvent extract by ATFD to recover the product or product intermediate in solid powder form;

5 4. Concentrating the solvent extract obtained in any step of production of chlorinated sucrose, and drying the concentrated extracts to recover the product or product intermediate in solid powder form; or

5. Drying the solution of chlorinated sugar, its derivatives or intermediates obtained otherwise than in the process of production of chlorinated  
10 sugars.

The detailed description and the specific examples given in a subsequent section, for the purpose of indicating specific embodiments of the invention, serve the purpose of illustration only. Accordingly, the present invention includes also those various changes and modifications which come within the  
15 spirit and scope of the invention that may become obvious to those skilled in the art from this detailed description.

#### **BRIEF DESCRIPTION OF DRAWINGS AND SHORTFORMS**

POCL<sub>3</sub> (POCl<sub>3</sub>) stands for Phosphorous oxy-chloride

ATFD stands for Agitated Thin Film Dryer

20 TLC stands for Thin Layer Chromatography

HPLC stands for High Pressure Liquid Chromatography

Fig. 1 illustrates the reaction scheme for the preparation of 1', 6'-Dichloro-1', 6'-

Dideoxy - $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside.

5 Fig. 2 illustrates the agitated thin film dryer used in the process of the present invention,

Fig. 3 is the flow sheet of the agitated thin film dryer;

Fig. 4 is the flow chart of the process of the present invention,

Fig. 5 is the IR Report of the product of the present invention; and

10 Fig. 6 is the HPLC Chromatogram of the product of the present invention.

Fig 7 is the XRD of crystalline form

Fig 8 is the XRD of amorphous form

15 **DETAILED DESCRIPTION OF THE INVENTION**

It is understood that the customary rules of interpretation of patent documents apply to this document also. However, some of those interpretations, which will expressly apply, are mentioned below.

Present invention is not limited to the particular methodologies, protocols, solvents, and reagents, etc, described herein as tools to achieve the claimed  
20 objective, as these may vary with change in context. Further, the terminology

used herein is used for the purpose of describing particular embodiments only, and is not intended to and shall not limit the scope of the present invention.

As used herein and in the appended claims, the singular forms "a" "an" and "

5 the" include plural reference also unless the context clearly indicates or requires or means otherwise. Thus, for example, a reference to "a process" is a reference to one or more processes for the stipulated objective and includes equivalents thereof known or obvious to those skilled in the art and so forth. Unless defined otherwise or contrary to the context, all technical and scientific  
10 terms used herein have the same meanings as commonly understood by one of ordinary skill in the art to which this invention belongs. Several methods, devices, and materials are described herein, although in practice or for testing of present invention, any methods and materials similar or equivalent to those described herein can be used. All documents cited herein are to be construed  
15 for reference and interpretation herein in their entirety

The process of drying under mild conditions applied to any liquid containing chlorinated sucrose derivative, either in substantially pure form or with other accompanying solid ingredients, is illustrated in Fig 4. Strategic use of some important modifications and the advantages of these modifications and  
20 subjecting the liquid solutions subjected to direct drying under mild conditions and certain other modifications introduced in the process, in the context of process efficiency, are as follows:

1. The reaction mixture of chlorination step, after completion of the reaction, can be subjected to drying under mild conditions either after or before deacylation step. This brings in significant improvement in process efficiencies, as it is more easy to handle a dry powder for further purification of the chlorinated sucrose or its intermediate in absence of solvent than in presence of solvent. It is pertinent to mention that the final product as well as inorganic salts formed during the process are both highly soluble in water. Hence, to extract the desired product completely from aqueous medium may be a difficult proposition. However, the extraction of solids (comprising of desired product or its intermediate and inorganic salts) by alcoholic organic solvent is better solution as selective extraction of the desired product will be more easy. The drying process requires less equipment, less consumption of energy, offers freedom from tediousness of crystallization processes in a batch or continuous operation. Several alternative procedures are available to adopt further course of operation either by extracting the chlorinated sucrose or its intermediate either by using a suitable organic solvent, ethyl acetate being preferable, or by supercritical extraction, or by dissolving the solids in water and subjecting the same to purification by column chromatography. Removal of the solvents by drying in above step is more convenient than by steam stripping adopted by Navia et al., in U.S. Pat. No. 5,498,709.
2. Further, once substantially pure solution of chlorinated sucrose or its intermediates or derivatives is obtained in the course of process of their

production, recovery of the product is very convenient, direct, total and most effective by resorting to drying under mild conditions than by recovering desired product by conventional crystallization from their concentrated solutions of those products as such or of their derivatives.

5 The process of drying gives substantially pure product directly in one step process in short time with least problems of control without any residual losses of solids; their purity, chemical properties and functional properties such as taste are same as the product obtained by conventional crystallization. This is a decided advantage in view of the  
10 cumbersomeness and expenses involved in conventional crystallization and in any process based on conventional crystallization.

3. Such substantially pure solutions of chlorinated sucrose or their intermediates, which could be submitted to drying under mild conditions for recovery of their solids for specific processing advantages, are  
15 obtained in the process illustrated in Fig 4 in the form of wash liquid coming out of chromatographic column when extracts obtained from solids of drying of chlorination reaction mixture are chromatographed and such wash liquid is evaporated and dissolved in appropriate volume of methanol.

20 In the methods preferred here for the illustration of this invention:

1. The chlorinated sucrose is 1', 6'-Dichloro-1', 6'- Dideoxy- $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside and also its acetate intermediates.
  2. Sucrose-6-ester is sucrose-6-acetate.
  3. The method of drying under mild conditions is Agitated Thin Film Drying, which involves evaporation achieved by using a vertical agitated thin film evaporator with hinged rotor blades.
  4. The reaction scheme in general involved in the manufacture of product from sucrose-6- acetate is given in fig. 1 of the accompanying drawings.
- Many permutations and combinations could be done in the indicated scheme, some of which, but not including all, are shown as illustration in the fig 1.

Various operations of the process of production of 1', 6'-Dichloro-1', 6 '-Dideoxy- $\alpha$ -D-Fructo- Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside are as follows:

The sucrose-6-acetate is chlorinated by the Vilsmeier reagent, which is prepared from Phosphorus Oxy Chloride ( $\text{POCl}_3$ ) or phosphorus penta chloride ( $\text{PCl}_5$ ). The sucrose-6-acetate is added to Vilsmeier Reagent at 5.degree.to 10.degree.C. After completion of the reaction, the reaction mass is heated to 80.degree. to 100.degree.C. and preferably between 90.degree.to 95.degree.C. and maintained for  $\frac{1}{2}$  -1hr and then the

temperature is raised to 110.degree.to135.degree.C. and preferably to 120.degree.to125.degree.C. and maintained for 3-5 hours.

Thereafter the reaction mass is cooled to room temperature and neutralized using alkali hydroxide or carbonate solution.

- 5 The desired product 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-  $\alpha$  -D-Galactopyranoside or its acetate, obtained after or before deacylation respectively, could be isolated by using the appropriate method mentioned in Methods 1 to 5 given as follows:

**Method 1:** When the reaction mass after chlorination is directly fed into  
10 ATFD, the product obtained was a solid mixture of 1', 6'-Dichloro-1',6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$  -D-Galactopyranoside-6-acetate and inorganic salts. The solids were treated with alcoholic solvents and filtered off to remove the inorganics. The alcoholic solution was then heated with appropriate organic alkoxides like sodium  
15 methoxide, sodium ethoxide, propoxides or its potassium analogs, during which the deacylation occurs to afford the desired product. The product could be isolated as a solid by either subjecting the alcoholic solution to the ATFD or the alcoholic solution could be further purified by column chromatography and the liquid eluted from the chromatographic column could be subjected to  
20 crystallization or direct drying by subjecting to ATFD.

**Method 2:** The solid mixture of 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-Chloro-4-Deoxy-6-acetoxy-  $\alpha$  -D-Galactopyranoside-6-acetate and



inorganic salts from the reaction mixture could be dissolved in water or the reaction solution can be further treated directly without ATFD drying with the alkali metal oxides like sodium hydroxide or potassium hydroxide or even with alkali earth metals like calcium hydroxide or barium hydroxide, etc. The resultant solution could be fed into the ATFD or spray drier to remove water and afford solids, where now essentially will be comprising of 1', 6'-Dichloro-1', 6'-Dideoxy- $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside (the product) and alkali or alkaline earth metal chlorides (NaCl, KCl or CaCl<sub>2</sub>). The product can be separated from inorganic chlorides by extracting the solids by organic solvents like methanol, ethyl acetate, acetone, etc and the product in the solvent extract can be further purified by column chromatography followed by crystallization or drying in ATFD.

**Method 3:** Yet another appropriate process was followed by adjusting the reaction mass to pH 7.5 – 9.0 and then subjecting the reaction mass to ATFD for solvent stripping. The product obtained being the mixture of desired deacylate of 1', 6'-Dichloro-1', 6'-Dideoxy- $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy- $\alpha$ -D-Galactopyranoside-6-acetate and inorganic salts. Effectively the deacylation was achieved in situ during the solvent stripping operations of ATFD. The solids obtained were treated with organic solvents to remove inorganic salts. The crude product after solvent stripping either by spray drying or ATFD was further purified after extracting solids in alcoholic solvents by column chromatography followed by crystallization or subjecting the chromatography column eluate to ATFD drying.

**Method 4:** Isolation of the pure 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate from solids containing 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate and inorganic salts in a process mentioned in methods 1 and 2 could also be achieved by direct column chromatography of the salts obtained from ATFD or spray drier.

**Method 5:** Isolation of the pure 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate from solids containing 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate and inorganic salts could also be achieved by dissolving the solids with water and extracting with organic solvents like dichloromethane, ethyl acetate and then stripping of solvent by drying by ATFD to get crude solid mixture. Isolation of the pure 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside from solids containing 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate can be achieved after followed by deacylation as mentioned in method 1 and 2.

**Method 6:** Isolation of the product 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-  $\alpha$ -D-Galactopyranoside from solids containing 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-  $\alpha$ -D-Galactopyranoside and inorganic salts could be done by dissolving the solids

obtained by using process described in Method 3 in water and extracting the product in organic solvent like ethyl acetate, dichloromethane, etc. This was followed by solvent stripping, column chromatography and crystallization.

Diagram of ATFD is shown in Fig. 2 of the drawings.

5 The detailed preferred process of ATFD is illustrated as follows:

Feed of the reaction mass was cooled to 5.degree.to10.degree.C. in the feed tank by circulating a brine solution. A pump was used to lift the feed from feed tank to the Dryer. The ATFD is a vertical Dryer with area of cross section 0.25 to 0.35 meter sqare. The feed enters tangentially and spreads along  
10 the inside surface of the shell in to a thin film. The rotor blades are hinged; the hinged rotor blades keep the film under intense agitation preventing any scale formation. The speed of the rotor was 1000 to 1500 revolutions per minute. The film progressively passes through different phases like liquid, slurry, paste, wet powder and finely powder of desired dryness, it is collected in a  
15 powder receiver.

The vapor flows countercurrent to the solids and was removed from the top of the Dryer. Distillate was collected from the condenser and solids are obtained from the Dryer. The distillate contains solvent and water. The distillate was subjected to fractional distillation, about 70-80% of solvent was recovered  
20 based on the input of solvent.

## **EXPERIMENT**

### **1. CHLORINATION OF SUCROSE-6-ACETATE**

100 g of sucrose-6-acetate was mixed with 200 ml of fresh solvent such as hexane, cyclohexane, pyridine, dimethyl formamide, and others, and particularly dimethyl formamide and Chlorination undertaken in a 3 liter 3  
5 neck round bottom flask. 500 ml of the solvent was charged. Thereafter, the solvent was cooled with stirring to 0.degree.to 5.degree.C. To this reaction mass, 166 ml of phosphorous oxy chloride (273.9 g) was added below 0.degree.C. To this chlorinating reagent, 100gm of sucrose 6-acetate in  
10 solvent was added below 10.degree.C. Thereafter, the reaction mass was stirred at 20.degree.to 25.degree. C. for ½-1 hr. Further, the temperature was raised to 70.degree.to 100.degree.to C. and preferably 80.degree.to 90.degree.C. and was maintained for 1 to 2 hr. Afterwards the temperature was raised to 110.degree.to 130.degree.C. and preferably 120.degree.to  
15 122.degree.C. and was maintained for 3 to 5 hr. The reaction mass was cooled to 40.degree.to 45.degree.C. and was neutralized.

### **2. ATFD REMOVAL OF SOLVENT**

The reaction mass obtained after completion of chlorination reaction, which approximates volume of 2-2.3 liter, was further treated in one of the following,  
20 including but not limited to, two alternatives:

a) pH is adjusted to 7.0-7.5 to obtain mixture of 1', 6'-Dichloro-1',6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$  -D-Galactopyranoside-6-acetate and inorganic salts;

b) pH is adjusted to 7.5 –9.0 to obtain mixture of 6-acetyl intermediate  
5 of 1',6'-Dichloro-1',6'-Dideoxy-  $\alpha$  -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-  $\alpha$  -D-Galactopyranoside and inorganic salts;

and the reaction mass was then fed to ATFD with the parameters, which are described, but not limited to, as follows:.

Area of ATFD = 0.20 - 0.50 meter square

10 Feed rate = 7-10 kg/hr

Pressure = 2 – 10 mm Hg.

Jacket temp = 70.degree.to100.degree.C.

Feed of 3 to 5 kg was cooled down to 5.degree.to 10.degree.C. in the feed tank by circulating the brine solution. pH of the feed was maintained at 7.0 to  
15 7.5 or 7.5 to 9; the pump was fitted to lift the feed from feed tank to the dryer. The dryer is a vertical dryer with area of cross section 0.25-0.35 square Meter. The feed entered tangentially and spreads along the inside surface of the shell in to a thin film. The rotor blades are hinged, the hinged rotor blades keep the film under intense agitation preventing any scale formation. The  
20 speed of the rotor was 1000-1500 revolutions per minute. Temperature was

maintained around 70.degree.to 100.degree.C. in the jacket by circulating hot water taking inlet from bottom, outlet through the top. The film progressively passed through different phases like liquid, slurry, paste, wet powder and finely powder of desired dryness. This was collected in a powder receiver.

- 5 The dry product, which was essentially, a mixture of 1', 6'-Dichloro-1', 6 '-Dideoxy- â -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy- â -D-Galactopyranoside-6-acetate and inorganic salts or alternatively deacylated 1', 6'-Dichloro-1', 6 '-Dideoxy- â -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy- â -D-Galactopyranoside-6-acetate and inorganic salts. This depends on the  
10 respective feed to the ATFD as described above.

The vapor flows countercurrent to the solids and was removed from the top of the Dryer. These vapors were condensed in the condenser. Distillate was collected from the condenser, solids were obtained from the Dryer. The distillate contains solvent and water.

- 15 The distillate was subjected to fractional distillation, about 70-80% of solvent was recovered based on the input of solvent.

**3. RECOVERY OF 1', 6'-DICHLORO-1', 6'-DIDEOXY- $\alpha$ -D-FRUCTO-FURANOSYL-4-CHLORO-4-DEOXY- $\alpha$ -D-GALACTOPYRANOSIDE FROM 6-ACETYL INTERMEDIATE, ITS DEACYLATION AND RECOVERY OF FINAL PRODUCT :**

5 This was achieved in four alternative ways exemplified as follows:

**3.1** The pH of the reaction mass after chlorination was adjusted to 7.0 – 7.5.

The reaction mass was subjected to ATFD to obtain 450g of mixture of 1', 6'-Dichloro-1', 6'-Dideoxy- $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy- $\alpha$ -D-Galactopyranoside-6-acetate and other inorganic salts. This powder  
10 was dissolved in 1.2 liters of water and complete dissolution was ensured. The solution was then extracted with 1 liter of ethyl acetate and layers separated. The aqueous solution was re-extracted with 400ml of ethyl acetate three times and all the ethyl acetate layers were pooled. The ethyl acetate was distilled off and the residue obtained was purified by column  
15 chromatography on silica gel. The purified 6-acetyl intermediate was deacylated with 10% sodium methoxide solution in methanol (pH 9 –10).

The deacylated product was concentrated and crystallized to obtain pure 1', 6'-dichloro-1', 6'-Dideoxy- $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside of 98.6% purity by HPLC and yield 30%.

20 **3.2** 450 g solids obtained from the ATFD which contains the 6-acetyl intermediate of 1', 6'-Dichloro-1', 6'-Dideoxy- $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy- $\alpha$ -D-Galactopyranoside and the inorganic salts were

dissolved in 500ml methanol three times. The methanolic extract was filtered to remove the inorganic salts.

The methanolic solution containing 6-acetyl product was treated with sodium methoxide at room temperature and was mixed till complete deacetylation.

5 The product was then concentrated to thick syrup and was taken for silica gel column chromatography. The purified fractions were collected, concentrated and crystallized to get pure product of 98.9% and yield 34%.

3.3 The pH of the chlorinated mass was adjusted to 8.5 – 9.0 and was fed to the ATFD. Solids obtained from ATFD, 450g, were extracted into 500 ml  
10 methanol three times. The methanol extract was filtered and concentrated and the residue was purified by silica gel column chromatography. The product obtained was 92% pure.

3.4 Solids from ATFD of the step of drying in example 3, 450g, were dissolved in 1.2 liter water and then extracted into 1:1 ethyl acetate. The aqueous solution  
15 was further extracted with 400 ml of ethyl acetate thrice. The ethyl acetate layers were pooled together and concentrated. The thick syrup obtained was purified by column chromatography to yield pure product of 93%.

#### 4. CHROMATOGRAPHIC PURIFICATION AND CHARCOALIZATION

Purification of liquids containing product or product intermediates with  
20 impurities was purified by column chromatography on silica gel or alumina using appropriate elution / desorption medium. The eluent coming out of the



column was given charcoal bed treatment and was then sent for either ATFD drying or for conventional crystallization.

#### **5. EXTRACTION OF PRODUCT FROM SOLIDS OBTAINED AFTER ATFD DRYING OF PURIFIED LIQUIDS CONTAINING THE PRODUCT**

- 5 The solid mass obtained from the ATFD, when the liquid subjected to drying contained almost pure product, was subjected to solvent extraction. The solvent used may be any organic solvent, including but not limited to, ethyl acetate, methanol, methyl ethyl ketone, and acetone. The preferred solvent used was methanol.
- 10 The solvent extracted mass was distilled in the rotary evaporator at low temperature. The syrup obtained was mixed with an appropriate column chromatography adsorbent like silica gel or alumina and run through column chromatography. The adsorbing agent could be any known column packing preferably alumina or silica gel. The preferable solvents for desorption are
- 15 ethyl acetate, mixture of toluene and methanol, mixture of methanol and ethyl acetate, mixture of methanol and dichloromethane. Ethyl Acetate was used in this work. The eluted fractions were collected in different receivers based on TLC showings. The fractions showing single spot on the TLC were collected separately. The solvent from this fraction was evaporated to provide a thick
- 20 syrup. The thick syrup was subjected to purification. Crude product obtained showed by TLC to have a high concentration of the desired product. This was subjected to crystallization.

The products that are extracted and purified by the above processes were and could be any one of the following i.e. 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside-6-acetate or its deacylated form i.e. 1', 6'-Dichloro-1', 6'-Dideoxy-  $\alpha$ -D-Fructo-Furanosyl-4-Chloro-4-Deoxy-6-acetoxy-  $\alpha$ -D-Galactopyranoside.

## 6. ISOLATION OF PRODUCT ACETATE OR THE PRODUCT IN POWDER FORM

- 10 The syrup obtained from the isolation stage was mixed with 3-5 volumes of mass of ethyl acetate and mixed well. The mass was distilled at low temperature to remove 2-4 volumes of ethyl acetate resulting in a liquid product concentrate. The desired dry product was obtained from the liquid concentrate by three methods,
- 15 a) Conventional crystallization, as reported as in the earlier patents cited in this document. Essential steps consisted of solvent distillation to form a product syrup, which was then dissolved in minimum quantity of appropriate solvent and then seeded with the product crystals for crystallization. The pure Crystals were recovered by centrifugation.
- 20 b) Feeding liquid product concentrate to ATFD to obtain the dry desired pure product of the acetyl intermediate or the desired deacylated product. This has

been reported for the first time in the co-pending application of these applicants No. PCT/N04/D064.

c) Spray drying the liquid product concentrate to obtain of the acetyl intermediate or the desired deacylated product, which has also been reported  
5 for the first time in the co-pending application of these applicants No. PCT/N04/D064.

In the conventional crystallization method the liquid concentrate was crystallized to obtain solid product. The product was filtered and dried under vacuum at 40.degree.to 50.degree. C.

## 10 **7. PROPERTIES OF THE PRODUCT OBTAINED THROUGH ABOVE EXPERIMENTS**

The solids isolated after drying the purified product containing liquids in the ATFD were also found to be identical in taste, organoleptically, and chemical analysis with the product obtained from the conventional crystallization method. Also the  
15 solids obtained after spray drying the liquid concentrate were found to be identical in taste and chemical purity with the desired pure product obtained from the crystallization and ATFD method. Solid powders obtained by ATFD and other methods of drying when compared to powders obtained from crystallization procedures were, however, amorphous in nature having smaller particle size.  
20 The average particle size of chlorinated sucrose, its derivatives and its intermediates was observed to be less than 20 microns, average particle size within a range of 5 micron to 12 microns, the residual moisture content was less

than 10%, more particularly to less than 5% and usually less than 0.5% up to 0.3%. This small particle size is obtained directly in crystallization or precipitation procedure and is not result of any milling after the crystals are obtained. The powder which appears as amorphous may also a microcrystalline in nature and  
5 composed of full range of particle shapes from totally amorphous though globular shapes to well defined needles. The product may further be milled to achieve more uniform particle size distribution. Residual solvent content of the product produced by the process describe above was below 0.1% usually 0.09%.

10 The crystalline form of the product is confirmed with the XRD plot as shown in Fig 7.

The particle size was evaluated in Microtrac – X100 equipment.

Properties of some of the batches of products are given below:

15

Table 1: Properties of conventional crystallization batch in process described in experiment no. (6.a):

Sl. No	TEST	RESULTS	SPECIFICATION
01	Appearance	White coloured crystals, taste sweet.	White to off white crystals, taste sweet.
02	Solubility	Complies	Soluble in ethanol and water. Slightly soluble in ethyl acetate.
03	Particle size		90% ≤ 9 microns
04	Specific Rotation	+86.03 <sup>0</sup>	Between +84 <sup>0</sup> to +87.5 <sup>0</sup>
05	Water content	0.22%	NMT 2%
06	Residue on ignition	0.04%	NMT 0.7%

07	Identification by IR	Complies	Complies with standard.
08	Identification by TLC	Complies ( Rf of both std & sam =0.72 cm)	Rf should complies with std
09	Other chlorinated disaccharides	Complies	NMT 0.5%
10	Chlorinated monosaccharides	Complies	NMT 0.1%
11	Triphenylphosphine oxide	Complies	NMT 150 µg/g
12	Methanol	0.09%	NMT 0.1%
13	Organoleptic	Passes the test	Passes the test
14	Purity	99.65%	NMT 98%
15	Arsenic	Complies	NMT 3 ppm
16	Heavy metals	Complies	NMT 0.001%
<b>MICROBIOLOGICAL SPECIFICATIONS</b>			
21	Total aerobic count	Nil	NMT 250/g
22	Yeasts	Nil	NMT 50/g
23	Molds	Nil	NMT 50/g
24	<b><u>Coliforms</u></b>	Nil	Negative test
25	<i>E.Coli</i>	Nil	Negative test
26	<i>S.aureus</i>	Nil	Negative test
27	<i>Salmonella</i>	Nil	Negative test

Table 2: The table below gives the data with respect to the individual crystal particle and their percentage

5

10%	0.956	60%	4.236
20%	1.541	70%	5.311
30%	2.093	80%	6.615
40%	2.605	90%	9.185
50%	3.274	95%	11.51

It is conclusive from the above results that the particle size of 90% of the crystallized product is below 9.185 microns.

10 Table 3: Summary results on particle size obtained from some other batches

Batch No.	Particle size
PP 02	90% $\leq$ 9.125 microns
PP 03	90% $\leq$ 9.165 microns
PRO 01	90% $\leq$ 9.035 microns
PRO 05	90% $\leq$ 9.183 microns

The particle size of crystals thus obtained from ethyl acetate crystallization conforms to the specifications.

- 5 Properties of amorphous product obtained by direct drying methods such as ATFD and spray drying:

The average particle size of chlorinated sucrose, its derivatives and its intermediates as was obtained from ATFD and or spray drying was observed to be less than 15 microns, average particle size within a range of 5 micron to 12  
10 microns, the residual moisture content was less than 10%, more particularly to less than 5% and usually less than 0.5% up to 0.3%. This small particle size is obtained directly after the said drying process and is not subjected to any milling after the dried powder is obtained. Also the spray drying or ATFD can be carried out on the pure product as well as in mixture with other suitable diluents or  
15 formulating agents. The powder which appears as amorphous may contain solvent content of below 0.1% usually 0.09%.

The XRD plot as shown in the figure no. 8 indicates no regular pattern, without any peaks, confirming that the product is amorphous in nature.

20

The chemical analysis of the solids from all the three methods showed the product purity or content was over 99% (HPLC Fig. 6 and IR Fig. 5 attached).

In a separate experiment, the ethyl acetate extract from after column chromatography was directly passed through ATFD. This also resulted in a desired pure product of high purity.

The solid product could be also isolated by feeding the ethyl acetate extract  
5 after column chromatography directly into the Spray Dryer or any other Dryer  
to afford the solid product.